

# CEMENT AND LIME

## MANUFACTURE

SCHOOL OF MINERAL ENGINEERING

University of Washington  
Seattle, Wash.

Vol. XXIV. No. 4

JULY 1951

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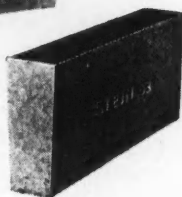
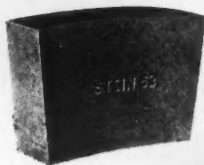
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PUBLISHED BY  
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14 DARTMOUTH STREET, LONDON, S.W.1

TELEPHONE: WHITEHALL 4581.  
TELEGRAPHIC ADDRESS:  
CONCRETUR, PARL. LONDON.

PUBLISHERS OF  
"CONCRETE & CONSTRUCTIONAL ENGINEERING"  
"CONCRETE BUILDING & CONCRETE PRODUCTS"  
"CEMENT & LIME MANUFACTURE"  
"THE CONCRETE YEAR BOOK"  
"CONCRETE SERIES" BOOKS.

VOLUME XXIV. NUMBER 4.

JULY, 1951

## Cellular and Air-entrained Concrete.

CONCRETE in which cells are purposely formed may contain a large proportion of little cells, as in lightweight cellular "gas" and aerated concrete, or a small proportion of much smaller cells as in air-entrained concrete. A requirement of a watertight cellular concrete is that the cells must be closed. The cells may be formed by mixing with the cement and aggregates an agent that produces a gas, as in gas concrete. The agent may also be a soapy material which forms bubbles of air, the bubbles being relatively large in lightweight foamed or aerated concretes or very fine in air-entrained concrete. The low specific gravity of gas and foamed concretes arises from the expansion consequent upon the chemical reactions which cause the cells to form and which are considered in the following.

### Chemical Constituents of "Gas" Concrete.

There are several methods of producing bubbles of gas in concrete and the theory of some of these is described by J. P. Levy in "Revue des Matériaux de Construction," No. 427.

The gas can be produced by adding powdered aluminium to the concrete. In the presence of the alkaline paste of the cement, the aluminium combines to produce tricalcium-aluminate ( $3\text{CaO}_2 \cdot \text{Al}_2$ ), and releases hydrogen. Powdered zinc is also used for this purpose, the reaction being catalysed by the addition of calcium chloride ( $\text{CaCl}_2$ ). Another method is to mix hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) with chloride of lime ( $\text{CaO} \cdot \text{Cl}_2$ ), which releases oxygen accompanied by the formation of water and calcium chloride ( $\text{CaCl}_2$ ). Another reaction used for producing gas is that between water and calcium carbide ( $\text{CaC}_2$ ), which forms acetylene ( $\text{C}_2\text{H}_2$ ) and calcium hydroxide, or hydrated lime [ $\text{Ca}(\text{OH})_2$ ].

It is generally necessary also to add a soapy substance to control the surface tension and counterbalance the tumultuous action during the generation of the gas. It is necessary, however, that the action shall not be too tumultuous, and it can be controlled. For example, consider the use of  $\text{H}_2\text{O}_2$  and  $\text{CaO} \cdot \text{Cl}_2$ . If the  $\text{CaO} \cdot \text{Cl}_2$  is added first and followed by the  $\text{H}_2\text{O}_2$ , the gas is generated rapidly and

considerable expansion takes place in the mixing apparatus and little in the concrete. If the procedure is reversed, the gas is generated slowly. It is necessary for the gas to be produced slowly so that none escapes and so that the generation is uniform throughout the concrete. An example of the volumetric proportions used by Dr. O. Graf is 100 kg. of cement, 1.1 l. of a 40 per cent. solution of  $H_2O_2$  containing 5 per cent. of soap, and 7.7 l. of milk of chloride of lime composed of 1 part by weight of  $CaO.Cl_2$  and  $1\frac{1}{2}$  parts of water.

Other requirements are that the process should not give rise to toxic or inflammable gases. Since the generation of oxygen might cause corrosion of reinforcement, the  $H_2O_2$ — $CaO.Cl_2$  method is not suitable for reinforced concrete and may cause corrosion of steel moulds. The use of powdered aluminium appears to be the most economical in material since about 500 g. of aluminium produces the same effect as 3 l. to 4 l. of  $H_2O_2$  and 20 l. of milk of chloride of lime. The aluminium-powder method requires careful proportioning, a fine siliceous sand, and possibly a setting accelerator, and is affected by temperature. The effectiveness of the  $H_2O_2$ — $CaO.Cl_2$  method does not seem to be affected by the size or nature of the aggregates.

The water-cement ratio of gas concrete is high, and may often exceed  $1\frac{1}{2}$ , but it is nevertheless advisable to use a cement that has high strength, especially tensile strength, in order to resist the shrinkage stresses. Experience in Germany indicates that the age and fineness of the cement affect the results obtained, but experience with a particular sand and method of manufacture alone can determine the most suitable cement. The presence of alkalis in the cement, instead of being deleterious, facilitates the generation of the gas.

#### Hydrogen-Peroxide Methods in Germany.

Reports published by the British Government immediately after the war describe developments in the manufacture of gas concrete in Germany. One method is to prepare a mixture of 185 kg. of silica sand, 100 kg. of ordinary Portland cement, and 91.5 l. of water. The fineness of the sand is such that 90 per cent. passes a sieve having 4900 meshes per square centimetre. The materials are mixed for 45 seconds, 1.05 l. of  $H_2O_2$  and 17 g. of saponine are added, and mixing is continued for a further 45 seconds. Then 8.5 l. of milk of chloride of lime are added and mixing is continued for a further minute. The milk of chloride of lime comprises 1 kg. of  $CaO.Cl_2$  to 2 l. of water.

A similar method is to mix very fine sand, cement, and water (in the proportions of 4 parts of sand to 1 part of cement by weight) for five to seven minutes after which period 40 per cent. of  $H_2O_2$  containing saponine is added and mixing is continued for two minutes. Calcium hypochlorite is then added in the proportions 1 : 8 or 1 : 12 of  $H_2O_2$  to calcium hypochlorite, and mixing continued for a minute.

#### Aerated and Air-entrained Concrete.

The agents used in foamed or aerated concrete and air-entrained concrete are emulsifiers or dispersers most of which are patented, and include natural and

synthetic resins, sulpho-acids of naphthalene stabilised by a silica gel, and soapy substances that are unaffected by lime, for example, albuminoids, saponine, and resinous soaps. Air-entrained concrete differs from foamed or ordinary aerated concrete mainly in that the air entrained is only 2 per cent. to 6 per cent. of the volume and the bubbles or cells are much smaller. The agent can be added at the time of mixing the concrete. Some American Portland cements in which an air-entraining agent is added during manufacture were described in this journal for November, 1949. In "Travaux" and "Cemento Hormigon," Professor Duriez recently described the composition of some air-entraining agents obtainable in the United States.

An agent called "Pozzolith," which is being used extensively for concrete at the new oil refinery at Fawley, Hants, is stated to be an insoluble powder formed by a mixture of pozzolana, calcium chloride, and calcium lignosulphonate. The calcium lignosulphonate is a by-product of pulp used for making paper and is the principal entraining agent. The pozzolana improves the workability, and the calcium chloride accelerates the hardening. A similar agent of Swiss manufacture is a liquid with a base of calcium-lignosulphonate but does not contain an accelerator.

Another agent, "Vinsol," is a resin extracted from a hydrocarbon. It is insoluble in water, and to enable it to be used in the mixing water of concrete it is mixed with a caustic-soda solution. "Darex" is a salt that is completely soluble in water and is obtained from a sulphonated hydrocarbon. In the form of a powder it can be mixed with the clinker of Portland cement before grinding, or it can be mixed in liquid form with the water when making concrete.

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## Portland Cement Specifications of the World.

### COMPRESSIVE AND TENSILE STRENGTHS.

In this journal for March, 1951, we gave tables of the strengths in lb. per square inch required by the standard specifications for Portland cement in various countries. On pages 58 to 60 of this number, we give the corresponding data in kilogrammes per square centimetre (*Table IIIA*). The dates of the standards are given in *Table I* (Chemical Composition) which was given on pages 26 to 29 of the March, 1951, number. Since these tables were compiled, revised standards have been published in the Netherlands and particulars were given in this journal for May, 1951.

TABLE IIIA.—STRENGTH OF PORTLAND CEMENT (KILOGRAMMES PER SQUARE CENTIMETRE).

NOTES.—For dates of Standards see Table I, published in this Journal for March, 1951.

(1) The following countries, which adopt the standards of other countries, are omitted: Egypt (O., as Britain, 1947); Iceland (O., as Denmark, 1933); India (O., as Britain, 1947); Jamaica (O., as Britain, 1947); Paraguay (as Argentina); Peru (as United States); South Africa (O. and R.H., as Britain, 1947); Austria (as Germany); Luxembourg (as Belgium); New Zealand (as Britain).

(2) Abbreviations of types of cement: H.S., high strength; L.H., low heat; L.S., low strength; M.L.H., moderate low heat; M.S.R., moderate sulphate resistant; O., ordinary; R.H., rapid-hardening; S.R., sulphate resistant; S.S., superior high strength.

(3) Strengths are measured on 3 sand: 1 cement mortar except where indicated otherwise. Tests marked\* are optional. c.s. = combined wet and dry storage.

Country (See Note 1)	Type of Cement (See Note 2)	Tensile Strength Age of specimen in days						Bending Strength Age of specimen in days				Compressive Strength Age of specimen in days					
		1	2	3	7	28	28 (c.s.)	1	3	7	28	1	2	3	7	28	28 (c.s.)
Argentina	O.	—	—	—	20	28	—	—	—	—	—	—	—	—	230	325	—
Australia	R.H.	20	25	30	35	—	50	—	—	—	—	225	350	400	450	—	600
	O.	—	—	—	—	—	—	—	—	—	—	—	—	—	176	246	316
	R.H.	—	—	—	—	—	—	—	—	—	—	—	—	—	281	387	457
Belgium	O.	—	—	18	23	27	—	—	—	—	—	—	—	—	200	300	400
	H.S.	—	—	23	27	30	—	—	—	—	—	—	—	—	300	400	500
	R.H.	20	—	27	30	32	—	—	—	—	—	225	—	400	500	575	—
Brazil	O.	—	—	—	—	—	—	—	—	—	—	110	—	220	310	—	—
	R.H.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Britain	O.	—	—	21-09	26-37	—	—	—	—	—	—	—	—	—	—	—	—
	R.H.	21-1	—	31-63	—	—	—	—	—	—	—	112-5	—	112-5	175-8	—	—
	L.H.	—	—	—	—	—	—	—	—	—	—	—	—	246-1	—	—	—
Bulgaria	O.	—	—	—	18	25	30	—	—	—	—	—	—	70-3	112-5	263-65	—
	R.H.	—	—	—	—	—	—	—	—	—	—	—	—	—	200	300	400
Canada	O.	—	—	25	30	40	—	—	—	—	—	—	—	250	—	400	500
	R.H.	—	—	14-1	19-3	24-6	—	—	—	—	—	—	—	—	—	—	—
	S.R.	19-3	—	26-4	—	—	—	—	—	—	—	—	—	—	—	—	—
	O.	—	—	10-5	17-6	24-6	—	—	—	—	—	—	—	—	—	—	—
Chile	O.	—	—	25	30	38	—	—	—	—	—	—	—	—	250	350	450
	H.S.	—	—	25	30	38	—	—	—	—	—	—	—	—	250	350	450
China	O.	—	—	18	25	—	—	—	—	—	—	—	—	—	180	275	—
	H.S.	—	—	25	30	30	—	—	—	—	—	—	—	—	250	400	—
	O.	—	—	18	25	30	—	—	—	—	—	—	—	—	200	275	350
Czechoslovakia	O.	—	—	25	28	30	40	—	—	—	—	—	—	—	275	375	425
	R.H.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	500

(See page 57)



[illegible]

†† 2 : 1 mortar.

1 litre sand.

I.      †† (60)  
(See page 57)

2.77 : 1 mortar.

† 2 (coarse) : 1 (fine) : 1 mortar.





## Determination of the Composition of Blastfurnace-slag Portland Cements.

THE following notes on methods of determining the proportion of blastfurnace slag in slag-Portland cements are based on an article in "Silicates Industrielles," No. 5, 1951, by Dr. P. Janssens, chief of the research department of S.A. Cimenteries et Briqueteries Réunies, Brussels.

An accurate and rapid method of analysis is essential if the proportion of slag in a slag cement is to be determined. Existing methods may be divided into those applicable when it is possible to analyse chemically the slag and clinker separately before mixing, and physical and optical methods employed when separate analysis is not possible.

Some chemical methods relate mainly to the determination of the sulphur or manganese content<sup>1,2</sup> of the slag, and other empirical methods are based on the different solubilities of clinker and slag in organic solvents<sup>3</sup>. The sodium-arsenite method<sup>2</sup> for determining the manganese content is a good method which can be applied to the slag and the clinker. Another good method, which is described in detail later, is to measure the reducing property by potassium permanganate in a sulphuric medium. Methods based on physical separation<sup>4</sup> result in obtaining each constituent in a pure state, but not quantitatively. A chemical method of analysis must then be applied to obtain the proportional composition, and consequently the time required to conduct such methods makes them of little practical value. An optical method<sup>5</sup>, however, is simple, rapid, and accurate, and improvements made to it are described in this article.

### Chemical Method.

The method of titration with potassium permanganate, which is based on a determination of the reducing properties, is rapid and accurate, and is applicable at works where samples of the clinker and slag can be taken before mixing. It is useful for ascertaining the regularity of the mixture. The reducing compounds in the slag are oxidised in the presence of concentrated  $H_2SO_4$  by an excess of permanganate, and an excess of sodium oxalate, which is titrated back by the permanganate, is added. The method takes ten minutes for each determination, and the degree of accuracy is 0.7 per cent. of the slag content.

The method has been improved in the author's laboratory. With mixtures of known slag and clinker content, the reducing properties of each mixture were expressed as a function of the slag content. The reducing property of the slag and clinker separately was also determined. The small divergence of the experimental results from theoretical results is explained by the fact that 20 ml. of  $KMnO_4$  were added whatever the slag content. This quantity is too great for cements having small slag contents and too small for cements having large slag contents. By altering the amount of permanganate to be added agreement was obtained. The amounts to be added are given in *Table 1*.

TABLE I

Percentage of slag	0 to 5	5 to 15	15 to 25	25 to 30	35 to 45	45 to 70	70 to 95	100
Quantity (ml.) of $\text{KMnO}_4$ ..	7.5	10	12.5	15	20	25	30	20

It seems that a binary clinker-slag effect must explain the fact that pure slag requires less reagent than a mixture containing 80 per cent. of slag.

The approximate reducing property of the mixture is determined by a preliminary test in which 20 ml. are added, and the amount of  $\text{KMnO}_4$  in the subsequent tests is based on this result. The reducing properties of the slags analysed were from 18 to 26 and of the clinker from 0.4 to 2.2. Therefore the reducing property of the two materials should be measured. It is necessary to standardise the period of contact between the cement and the permanganate after the addition of the sulphuric acid if it is desired to obtain good reproducibility. Two minutes is the optimum period.

The method of conducting the test is as follows. The metal particles are extracted by a magnet from the slag, clinker, or cement being analysed. The sample is dried by being subjected to a temperature of 110 deg. C. for an hour. After cooling, 1 gr. of clinker or cement, or 0.5 gr. of slag, is placed in a 250-ml. beaker, 100 ml. of distilled water are added, and the mixture is stirred. A  $\text{KMnO}_4$ -solution (4.5 gr. per litre), which has been standardised with oxalate, is added, the quantity being 5 ml. for the analysis of clinker and 20 ml. for slag or cement. For cement, a preliminary test is needed and the amount of  $\text{KMnO}_4$  required to obtain an accurate determination is adjusted. The quantity (ml.) of  $\text{KMnO}_4$  to be added for final test are as given in Table I if the percentages of slag are those determined by the preliminary test.

The next step is to add slowly 20 ml. of concentrated  $\text{H}_2\text{SO}_4$ . The colour of the solution should be deep pink or purple, but if it is pale or colourless the test must be repeated with a greater quantity of  $\text{KMnO}_4$ . Stir for exactly two minutes and then add 15 ml. of sodium-oxalate solution if 20 ml. of  $\text{KMnO}_4$  have been used, or 10 ml. if 5 ml. of  $\text{KMnO}_4$  have been used. (The sodium-oxalate solution should contain 9 gr. of oxalate and 25 ml. of  $\text{H}_2\text{SO}_4$  per litre.) The solution should be colourless, but if it is coloured more oxalate should be added. Titrate back with  $\text{KMnO}_4$  until a pink coloration persists for about 30 seconds. The heat of dissolution of the sulphuric acid is sufficient to produce the temperature required for the titration. A double back-titration is made because it is easier to determine the end of the reaction by the appearance of the pink coloration than by its disappearance.

If  $x$  is the quantity (millilitres) of  $\text{KMnO}_4$  and  $y$  the quantity (millilitres) of oxalate, the reducing property of the slag is  $2(x - y)$ , and of the cement  $x - y$ . The percentage of slag is calculated from  $\frac{100(R_c - R_K)}{R_s - R_K}$  where  $R_c$ ,  $R_K$  and  $R_s$  are the reducing properties of the slag-cement, clinker, and slag respectively.

The reproducibility of the reducing property is within 2 per cent. The reducing property of slag-cement is mainly due to the slag but may to a slight extent be due to the clinker and gypsum.

### Optical Method.

The improved optical method described in the following is applied to the determination of the proportion of slag in cement, the nature and analysis of the constituents of which are not known. The principle is to determine the number of grains of slag, for which purpose it is essential to use a specimen in which the grains are of regular size. The number of grains of cement and slag in the field of a microscope are counted by a micrometer eyepiece. The number of grains of each substance multiplied by the density of each gives the percentage by weight. Since the specimen examined may not necessarily be representative, the results are corrected as described later.

Since the magnification required is only fifty times, a simple microscope with a condenser and, if possible, a diaphragm is required. The eyepiece must contain a grid forming a hundred distinct regular squares in the field of observation. The degree of illumination is important in view of the transparency of the vitreous grains of slag which may not be seen in a field too brightly illuminated. The best results are obtained by placing a sheet of ground glass between the source of light and the mirror of the microscope to make the lighting uniform and soft. When counting the yellowish-brown grains of clinker the lighting may be direct, but for the grains of slag the lighting should be slightly oblique.

The grains of clinker are irregular and angular and are in small masses of crystals, the component crystals often being recognisable. The grains of slag differ, but most frequently are light, homogeneous, glassy, transparent particles with clean fractures. Some grains are stained yellow by iron, or violet by manganese, but the uniformity and homogeneity of the particles prevent confusion with grains of clinker. Some grains may be marked with black and grey dots. The refraction index of slag varies from 1.6 to 1.66. There is a similarity in appearance between the grains of slag and gypsum, and special chemical treatment is needed to distinguish them.

For the microscopic examination it has been found that the best results are given by the intermediate granulometric fraction between 60 microns and 88 microns (corresponding to sieves having 4,900 and 10,000 meshes per square centimetre). About 25 mg. of the intermediate fraction are mounted either with Canadian balsam or glycerine. The optimum number of grains of the intermediate fraction covered by the grid is 100 to 125. A count of 1,000 particles is sufficient for analysing the intermediate fraction and takes about fifteen minutes. The proportion of the intermediate fraction in relation to the whole varies from 6 per cent. to 30 per cent. for commercial slag-cements, and it may seem questionable whether the results obtained from this fraction are representative of the whole. It is found that, if the clinker and slag are ground separately to the same degree of fineness in a laboratory and mixed after grinding, the intermediate fraction is representative of the whole. In simultaneous grinding of clinker and slag in a

laboratory, the intermediate fraction gives slag contents higher or lower than the actual content. In commercial grinding the intermediate fraction gives a slag content up to 20 per cent. in excess of the actual content.

It is necessary to be able to distinguish additives from the slag and cement. Although grains of gypsum resemble the grains of slag, they are very friable and most of them are in fine fractions. The intermediate fraction contains only half the gypsum, and it is possible to colour, and thereby distinguish, 20 per cent. of the gypsum by Gonell's reagent. Some manufacturers of slag cement add sodium sulphate instead of gypsum; the appearance of the grains of  $\text{Na}_2\text{SO}_4$  is similar to that of gypsum or slag, but a simple treatment with water makes it possible to distinguish them because of their solubility. The addition of calcium chloride does not usually exceed 1 per cent. and is therefore neglected in the analysis. Particles of iron are in the form of opaque shiny grains and are identified by moving a magnet over the specimen.

If the number of grains of slag counted is  $a$  and the specific gravity of the slag is 2.8, and if the number of grains of clinker is  $b$  and the specific gravity 3.1, the percentage of slag  $L$  is given by  $\frac{100 \times 2.8a}{2.8a + 3.1b}$  and the percentage of clinker  $C$  is given by  $\frac{100 \times 3.1b}{2.8a + 3.1b}$

If the gypsum content  $G$  of the cement is known,  $\frac{G}{2}$  should be subtracted from  $L$  to give the more accurate percentage of slag. To extrapolate the results of the intermediate granulometric fraction analysed to the whole of the cement,  $L - \frac{G}{2}$  should be multiplied by 0.88 or, if greater accuracy is required, the reducing property must be determined by the permanganate method previously described. Let  $M$  be the reducing property of the cement and  $N$  the reducing property of the intermediate fraction; then  $\frac{M}{N} (L - \frac{G}{2})$  is the actual percentage of slag in the cement.

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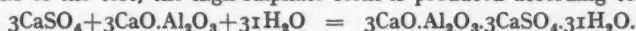
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## A Test of the Resistance of Portland Cement to Sulphate Attack.

IN the Journal of Research of the United States National Bureau of Standards for September, 1950, Mr. W. C. Taylor and Mr. R. H. Bogue described a test by which the resistance of Portland cement to attack by sulphates can be rapidly determined. The usual methods of testing specimens of mortar and concrete require a period of several weeks for their completion, but the test described can be performed in a day and is made on the cement and not on concrete or mortar. Briefly the new method is to determine the amount of dissolved  $\text{SO}_3$  rendered insoluble by reaction with aluminates when cement is shaken in lime-water. The following is an abstract of the paper.

The resistance of concrete to sulphate attack depends on chemical and physical factors. The cement paste may contain materials reactive to sulphate solutions, but the life of concrete exposed to such solutions may be prolonged by devices that give greater permeability or greater constancy of volume or may be shortened by the use of lean mixtures and the presence of expansive constituents.

The principal chemical cause of the disintegration of concrete in sulphate waters is the reaction between the sulphate ions in the presence of calcium-hydroxide and the alumina-containing phases of the cement that dissolve in the solution. Crystalline tricalcium-aluminate is less resistant to attack in sulphate solutions than is the same compound in the glassy state, whereas crystalline tetracalcium-alumino-ferrite is more resistant to such attack than its glassy counterpart. Alumina in the form of the tricalcium-aluminate is less resistant to attack in sulphate solutions than it is when in the form of the tetracalcium-alumino-ferrite. Calcium-sulphate and tricalcium-aluminate, in the presence of calcium-hydroxide (which is always present in cement paste owing to the hydrolysis of tricalcium-silicate), react to form calcium-sulphoaluminate. Under the conditions of the test, the high-sulphate form is produced according to the equation



If a constant  $\text{SO}_3$ -concentration in the solution is assumed, the rate and extent of this reaction increases as the amount of alumina that enters the solution in a given time increases. Since this amount varies with the state of the tricalcium-aluminate and is also affected by the presence of crystalline or glassy iron-alumina solid solutions, the reaction cannot be defined by a proportionality factor applied to the  $\text{Al}_2\text{O}_3$  or  $3\text{CaO} \cdot \text{Al}_2\text{O}_3$  present.

### Description of Test.

The  $\text{SO}_3$ -content of the cement to be tested is first determined by any acceptable procedure. About 30 g. of standard Ottawa sand, or similar silica sand, is placed in a dry 100-ml. graduated cylinder fitted with a clean rubber stopper. (A blank determination should be made with each quantity of sand employed.) A sample of cement, equal in weight (grammes) to 5.4 divided by the percentage of  $\text{SO}_3$  in the cement, is placed in the cylinder containing the sand, and 100 ml. of saturated lime-water is measured in a 100-ml. pipette and added rapidly to the



cylinder by inverting the pipette. The stopper is inserted and the mixture is at once shaken vigorously by hand. The cylinder is then fastened to a rotary shaker operated at 60 r.p.m. for six hours from the time of the addition of the lime-water. The shaker should be designed so that the cylinder is not more than 6 in. from the hub. To obtain consistent results the test must be made at constant temperature. Just before the end of the 6-hour period, a 9-cm. No. 42 filter paper is inserted in a Buchner funnel and moistened with distilled water. Suction is applied, and the contents of the cylinder are poured into the funnel. The cylinder is washed with 50 ml. to 60 ml. of distilled water and the washings poured on to the funnel. This step is repeated once.

The filtrate is transferred to a 600-ml. beaker. The filter flask is washed twice with 50 ml. to 60 ml. of distilled water and the washings added to the filtrate. The volume is then made up to about 350 ml. and 5 ml. of concentrated HCl is added. The weight of  $\text{SO}_3$  is determined by precipitation with  $\text{BaCl}_2$ -solution in accordance with the standard procedure. When the amount of  $\text{SO}_3$  remaining in the solution has been determined, the amount is subtracted from the amount of  $\text{SO}_3$  in the sample of the cement and this difference is assumed to be the quantity of  $\text{SO}_3$  that has reacted to form calcium sulphoaluminate during the period of the test. This quantity is calculated as a percentage of the  $\text{SO}_3$  originally in the cement and is called the sulphate-reaction value, and is reported to the nearest whole number.

#### Comments on the Test.

From investigations made by the authors on laboratory and commercial cements the usefulness of the test as an index of the resistivity of cements to attack by sulphate solutions is confirmed. Since sulphate attack is associated with the interaction between the sulphate and aluminate in saturated lime-water, a measure of that reaction may be expected to reveal the intrinsic sulphate reactivity of the cement. It is emphasised that the test does not indicate the resistivity that may be produced in concrete and mortar by physical means, nor does it indicate the life of specimens in sulphate solutions, insofar as the life is affected by the constituents of the cement (such as periclase) or of the aggregate (as reactive siliceous materials).

By correlations with performance tests, it is concluded by the authors that cement having a sulphate-reaction value up to 50 may be considered as relatively resistant to sulphate attack (the lower the value, the greater the resistivity of the cement). Concrete or mortar made with such cement may be expected to have satisfactory durability when exposed to sulphate waters, unless factors other than sulphate reaction may cause disintegration. Cement having a sulphate-reaction value between 50 and 65 is of doubtful sulphate resistivity. Concrete and mortar made with such cement may be durable if exposed to sulphate attack if they are dense and impermeable, and are free from other disintegrative agents. Cement having a sulphate-reaction value of over 65 should be considered as relatively non-resistant to sulphate attack (the higher the value, the lower the resistivity of the cement). Concrete and mortar made with such cement may be expected to have a relatively short life when exposed to sulphate waters, regardless of the quality of the workmanship or the presence of beneficial agents.



## The Cement Industry in Britain.

THE following notes are from the statement of the chairman, Mr. George F. Earle, at the annual meeting of the stockholders of the Associated Portland Cement Manufacturers, Ltd., held in London on May 31.

The price of cement, not including packing, is now 87 per cent. higher than pre-war, while building materials as a whole show an increase of 130 per cent. and the cost of manufactured articles an increase of 126 per cent. Before the war paper bags cost 2s. 6d. per ton of cement—now they cost 17s. 6d. This is almost entirely due to the increased cost of paper, which has gone up from £17 to £132 a ton. It is most disappointing that customers have to pay these prices when they buy cement; there seems no likelihood of a fall in prices until the new capacity for pulp production is working. Considerable sums are being spent on special lorries and other means of delivering cement in bulk, and so save the importation of pulp and paper at this fantastic price.

Last year, with almost the same plant as before the war, we produced in Britain an additional million tons of cement compared with the best pre-war year, while the improvement over 1949 was nearly 300,000 tons. This was done by means of better organisation and more mechanisation. Output per man per week is now 23 per cent. better than the best pre-war year, and it seems that we are doing as well as our friends in the U.S.A. I know of no other productive industry which can say that. Coal consumption is less than before the war.

The new works at Shoreham is now at almost full production. The frightening increase in the cost of machinery has made the works more costly than was expected when work was started nearly four years ago—but in spite of that the cost per ton of cement compares well with that of other works which have been built since the war by other people—although the very similar works in South Africa and Mexico cost considerably less per ton of cement.

In South Africa, the production at Lichtenburg has been up to expectations of quality, quantity, and cost. In Mexico the new works is running satisfactorily. The board of the company there take an optimistic view of the future, and it seems probable that they will decide to extend the works. The domicile of the Australian Company was transferred to that country during 1950. This company is proceeding with the erection of a new kiln, and changing the works from the dry to the wet process. Apart from increasing the output, it is expected that this will improve the quality of the product. Progress on the new work is slow, owing to the shortage of labour. In New Zealand there has been much delay in settling the details of the extensions of the works of the Golden Bay Cement Company. This has now been done, and an increase of 100,000 tons a year is planned. In British Columbia a new 350-ft. kiln is being installed. This will increase the capacity of the works by 175,000 tons a year, and production will then be approximately equal to the anticipated demand.

In Malaya the new company has been formed in Singapore.

## The Pneumatic Method of Conveying Cement.

THE use in Switzerland of the pneumatic-slide method of conveying cement in a cement works is described by V. R. Pfrunder in "Zement-Kalk-Gips" for March 1951. The principle of the method is shown in Fig. 1. Air at a pressure equivalent to 160 mm. to 200 mm. of water is blown along an air duct (a), passes upwards through porous plates (b), and mixes with the particles of cement in duct (c). This action overcomes the internal friction between the particles, and the cement flows towards the lowest point of the cement duct which is inclined at an angle of about 4 deg. The duct is covered with metal sheets (d) fitted with filters which ensure that the air exhausts

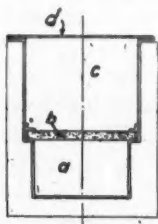


Fig. 1.—Section through "Air-slide".

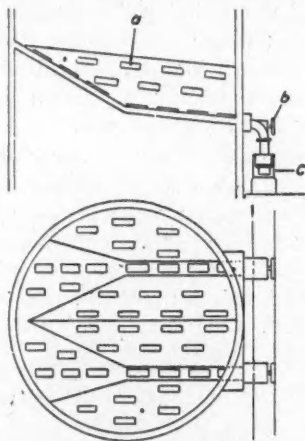


Fig. 2.—Sectional Elevation.

easily into the atmosphere. The ducts have been built up to 328 ft. long, and bends and outlets may be incorporated.

The porous plates have in the past been made of ceramic materials, or a fabric diaphragm has been used. Towards the end of the war these materials were unobtainable in Switzerland, and experiments were made with precast cement-mortar plates. After many trials, the most satisfactory composition of the mortar was found to be 3350 gr. of sand, 1100 gr. of cement, and 400 gr. of water. The sand was graded as follows: 1.7 per cent. greater than 0.5 mm., 64.7 per cent. from 0.2 mm. to 0.5 mm., and 33.6 per cent. less than 0.2 mm.

Experiments were also made to find the best type of mortar plate for use in ducts built into the walls and bottoms of cement silos. Air is pumped into the ducts and passes upwards through the plates into the cement, which is loosened, and flows more easily into the pneumatic-slide ducts. The composition of the mortar which gave the best results was 3600 gr. sand, 900 gr. of cement, and 315 gr. of water. The grading of the sand was 0.8 per cent. greater than 0.75 mm., 82 per cent. from 0.5 to 0.75 mm., and 16 per cent. smaller than 0.5 mm.

Fig. 2 shows a cement silo 82 ft. high in which the two types of plates were used in the ducts. Plates (a) are for loosening the cement in the silo bottom, and (b) is the outlet valve. The cement is transported by pneumatic slide (c) for a distance of 164 ft. from the silos to the packing plant. The pneumatic slide has a capacity of 60 tons per hour, the air being supplied by a fan driven by a 3 h.p. motor.

An advantage of this method of transporting cement is the cooling which occurs as the air mixes with the cement, and which is of importance when cement has to be used directly from the mills. The author states that, in his experience, pneumatic slides appear to be the cheapest and cleanest way of transporting cement.

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### The Cement Industry Abroad.

ANGOLA.—It is expected that a cement factory being built at Lobito will be completed by the end of this year. The initial production will be at the rate of 80,000 tons a year.

COSTA RICA.—It is reported that a proposal to build a cement factory in Costa Rica has been abandoned on the ground that the cost of manufacture would be higher than the cost of imported cement.



## Line of route delivery

● Water, gas and electricity installation or renewal schemes need good transport co-operation and British Railways can supply it. They convey and deliver on line of route, cables, conduit covers and pipes, besides bricks, cement and kindred commodities. Bulk deliveries of road dressing materials are made to site, including barrels, which are collected after use. Storage for contractors' tools and materials is available at central railheads. A word to your local Goods Agent will set the wheels turning.

BRITISH RAILWAYS

**CUBA.**—Due to an increase of 6,500 tons a month (from 28,500 tons to 35,000 tons) of the cement production in Cuba, it is expected that imports of cement will be reduced by 5,000 tons a month in the second half of the year 1951.

**INDONESIA.**—Included in the programme for setting up new industries in Indonesia is a plan for building a new cement factory with a capacity of 200,000 tons a year. It is stated that the existing factory at Padang can produce only half of the country's requirements, which are estimated at 400,000 tons a year. The Government hopes to be able to start work on the new factory during this year.

**JAPAN.**—The production of cement in Japan during the year ended March 1951 was nearly 5,000,000 tons, of which 696,000 tons were exported. It is reported that the demand for cement in Japan and abroad is heavy and increasing, and that it is hoped to increase the production to 6,000,000 tons.

**PAKISTAN.**—Included in a two-years' development plan announced by the Minister of Finance and Economic Affairs is the erection of two more factories for the manufacture of Portland cement.

**URUGUAY.**—Due to a serious scarcity of cement, the Administración Nacional de Combustibles Alcohol y Portland has been authorised to invite tenders from abroad for the supply of 12,000 tons of ordinary Portland cement.

**TURKEY.**—The government of Turkey has allocated about £700,000 for the erection of a cement factory, with an annual capacity of 150,000 tons, at Izmir. Permission has also been given for the extension of the Zeytinburne and Darica cement works at Istanbul at a cost of about £900,000.

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